January 1976

SUNFLOWER RESEARCH IN THE SOUTHERN HIGH PLAINS--

A PROGRESS REPORT

USDA Southwestern Great Plains Research Center
Bushland, Texas

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U. S. Department of Agriculture
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1/ This report was prepared for the Sunflower Forum held in Fargo, North Dakota, on January 7 and 8, 1976. It is to be published in, and, should be cited as part of, the Sunflower Forum Proceedings (pages in the Proceedings have not been determined). This report is a contribution from the Soil, Water, and Air Sciences, Southern Region, Agricultural Research Service, USDA, in cooperation with The Texas Agricultural Experiment Station, Texas A&M University.

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INTRODUCTION

Sunflowers are a relatively new crop on the Southern High Plains. From 1969 to 1973, few sunflowers were planted In 1974, about 7,000 acres were grown, primarily in Texas. In 1975, sunflowers were grown on about 350,000 acres (Smith, 1975).[3/] Along with the tremendous increase in sunflower acreage arose a need for research regarding sunflower production practices in the Southern High Plains.

Sunflower research was initiated at the USDA Southwestern Great Plains Research Center at Bushland, Texas, in 1974, and expanded in 1975. The results presented in this report are based on 1 year's data. Hence, no major conclusions are warranted. All studies at Bushland were conducted on Pullman clay loam. The soil slope was about 0.15% in all studies, except for the fertility study where the slope was about 0.7%. In irrigated studies, the sunflowers were furrow-irrigated through gated pipe.

3/ Smith, Joe. 1975. Agricomments. The Sunflower 1(2):16-17.

PLANTING DATE STUDY FOR IRRIGATED SUNFLOWERS--1975

In this study, Hybrid 896 sunflowers were planted every 2 weeks, from March 21 to July 28. The sunflowers were planted (three replications) with unit planters in rows spaced 40 inches apart at rates to obtain 26,000 plants/acre. The sunflowers were irrigated as needed to prevent plant wilting and were sprayed as needed with methyl parathion for sunflower moth control. Sprayings were made on July 1 and 7 (plantings 1, 2, and 3), July 21 (plantings 4 and 5), and July 28 (plantings 5 and 6). Only minor sunflower moth populations were noted in later plantings. Samples for yield determination were hand-harvested from 10 feet of two rows/plot, dried, and threshed with a stationary thresher. Planting dates, days to flowering after emergence and full flowering, seed yields, seed test weights, and seed oil contents are given in Table 1. Yields are adjusted to 9% seed moisture content.

Because of low soil temperatures, sunflowers planted on March 21 required 25 days for emergence. Those planted on April 4 emerged in 12 days (Figure 1). For later plantings, emergence time decreased to 4 to 6 days. Lapsed time between emergence and flowering was shorter for sunflowers planted during May, June, or July than for those planted earlier. Except for the July 28 planting for which time from first to full flowering was similar to that of the early plantings, time from first to full flowering was shorter for the late plantings than for the early plantings.

Seed yields were not affected by planting dates between March 21 and May 29, except for the May 16 planting. Reasons for the significantly higher yields for the May 16 planting are not apparent. Beginning with the June 12 planting, yields decreased steadily for the late-season plantings. Sunflowers planted on July 28 were damaged by a freeze on October 25, which undoubtedly reduced yields. Also, caterpillars stripped leaves from sunflowers planted on July 16 and 28, soon after full flowering.

Late-June and mid-July plantings resulted in over 1,000 lb seed/acre, which suggests that sunflowers may be a satisfactory crop for use in a double cropping system after wheat when wheat is harvested near the end of June.

Table 1. Time to flowering and full flowering and seed yields, test weights, and oil contents for sunflowers planted on various dates at Bushland, Texas, in 1975.

Plantings		Time to		Seed yield	Test weight	Total oil content
		Flowering after emergence	Full flowering[1/]			
No.	Date	Days	Days	lb/acre	lb/bu	%
1	March 21	62	15	2259 b[2/]	30.9 ab	48.9 a
2	April 4	63	17	2300 b	31.6 a	48.6 ab
3	April 18	59	15	2228 bc	30.9 ab	47.4 ab
4	May 2	53	16	2143 bc	29.9 bc	44.5 c
5	May 16	48	10	2790 a	27.0 d	44.5 c
6	May 29	48	11	2309 b	24.7 e	42.9 c
7	June 12	46	9	1789 cd	27.5 d	44.6 c
8	June 27	45	6	1558 d	28.8 c	46.8 b
9	July 15	43	9	1110 e	25.0 e	39.2 d
10	July 28	49	17	816 e	23.9 e	35.4 e

1/ Time required for sunflowers to reach full flowering after start of flowering.

2/ Means followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).

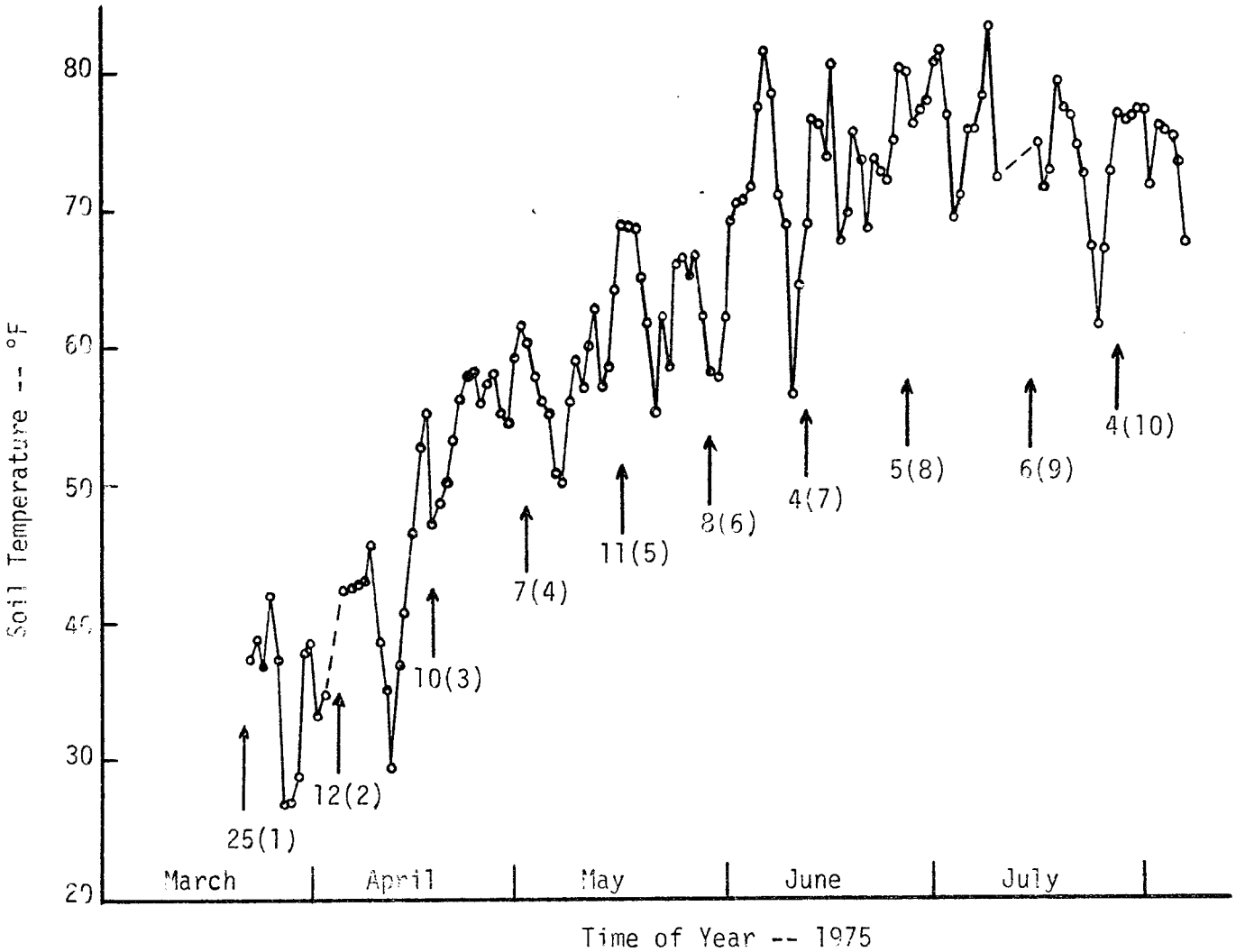

Figure 1. Soil temperatures (average of daily maximum and minimum) at the 2-inch depth of the seed zone in the sunflower planting date study at Bushland, Texas, in 1975. Arrows are placed on planting dates, numbers at arrows indicate days to emergence, and numbers in parentheses correspond to planting number given in Table 1.

Seed test weights were generally highest for the early plantings and decreased somewhat irregularly for the May 16 and later plantings. Seed oil contents were highest for the first planting and decreased with later plantings, until the June 27 planting, for which the oil content increased. Oil contents significantly decreased for the July 15 and July 28 plantings.

IRRIGATION TIMING STUDY--1975

Hybrid 896 sunflowers were planted with unit planters on May 12 in rows spaced 40 inches apart at rates to obtain 26,000 plants/acre. Treflan had been incorporated before planting the sunflowers. Irrigation treatments were:

E	--- emergence irrigation only
EB	--- emergence plus one irrigation at early budding
EF	--- emergence plus one irrigation at early flowering
E(F + 14)	--- emergence plus one irrigation 14 days after start of flowering
E + 3	--- emergence plus three growing season irrigations

The emergence irrigation was applied on May 13 to promote seed germination and seedling emergence. Each treatment was replicated four times.

Soil water contents were determined gravimetrically on samples obtained by 1-foot increments to a 6-foot depth on June 3 and after harvest. Sunflowers were sprayed for moth control on July 21 and 28. Samples for yield determination were hand-harvested from 10 feet of two rows/plot. After drying, the samples were threshed with a small stationary thresher. Seed yields (adjusted to 9% moisture), test weights, and oil contents are given in Table 2. Also included are the total water used by the sunflowers (growing season irrigations, precipitation, and soil water changes), and water efficiencies based on seed yields and total water used.

All sunflowers receiving one or more growing season irrigations yielded more than those irrigated for emergence only. In addition, delaying one growing season irrigation until early flowering increased

Table 2. Seed yields, test weights, and oil contents; growing season water use; and water efficiency for sunflowers grown under irrigation at Bushland, Texas, in 1975.

Treatments[1/]	Irrigations		Seed yield	Test weight	Total oil content	Growing Season Water Use				Water Efficiency
						Irrigation	Precipitation	Soil water	Total	
	Date	inches	lb/acre	lb/bu	%	inches	inches	inches	inches	lb/acre-inch
E	May 13	3.0	1411 d[2/]	24.6 b	42.5 b	--[3/]	8.3	6.9	15.2	92.8
EB	May 13 July 1	3.0 2.6	1963 c	26.3 a	43.1 b	2.6	8.3	7.8	18.7	105.0
EF	May 13 July 16	3.0 3.1	2469 b	26.3 a	44.9 b	3.1	8.3	8.3	19.7	125.3
E(F + 14)	May 13 July 30	3.0 3.1	2738 ab	27.9 a	47.4 a	3.1	8.3	8.1	19.5	140.4
E + 3	May 13 June 26 July 16 July 30	3.0 3.1 3.1 3.1	2970 a	27.4 a	45.0 b	9.3	8.3	7.4	25.0	118.8

1/ Treatments were: E---emergence irrigation only; EB---emergence plus one irrigation at early budding; EF---emergence plus one irrigation at early flowering; EF + 14---emergence plus one irrigation 14 days after start of flowering; and E + 3---emergence plus three growing season irrigations.

2/ Means followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).

3/ The emergence irrigation was applied before soil water contents were determined. Hence, the emergence irrigation is not included in growing season water use.

yields by 506 lb/acre over those obtained from one irrigation at early budding. Yield increased 269 lb/acre more when the single growing season irrigation was delayed until 14 days after the start of flowering. Three growing season irrigations resulted in only 232 lb/acre more seed production than the single irrigation 14 days after the start of flowering. Consequently, water was used more efficiently when single irrigations were applied during flowering than when the sunflowers were more frequently irrigated. Seed of sunflowers irrigated during the growing season had higher test weights than did sunflowers irrigated for emergence only. Seed total oil content of sunflowers irrigated 14 days after start of flowering was significantly higher than that of the other treatments.

Soil water determinations showed that sunflowers used water from soil to at least the 6-foot depth and possibly even to a greater depth. However, water contents were not determined below 6 feet (Figure 2).

PERFORMANCE TRIAL--1975

Included in the Sunflower Performance Trial were the 11 entries (9 hybrids and 2 varieties) common to Performance Trials at other locations. Hybrid 896 and an experimental hybrid (cms89 x RHA 272) were included in the trial because Hybrid 896 was used in other studies at Bushland in 1975 and the experimental hybrid performed well in a study at Bushland in 1974 (Unger, Jones, and Allen, 1975).[4/]

Treflan was incorporated before the sunflowers were planted on May 12 with a belt planter at rates to obtain 26,000 plants/acre. Row spacing was 40 inches and plots were four rows wide and 25 feet long. The treatments were replicated four times. An irrigation to promote germination and seedling emergence was applied on May 13. Growing season irrigations were applied on June 26, July 16, and July 30. Irrigations totaled 12.2 inches and precipitation totaled 8.3 inches. The sunflowers were sprayed with methyl parathion for sunflower moth control on July 21 and 28. Yields were determined from samples obtained from 10 feet

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4/ Unger, Paul W., Ordie R. Jones, and R. R. Allen. 1975. Sunflower experiments at Bushland on the Texas High Plains---1974. Texas Agricultural Exp. Sta. PR-3304.

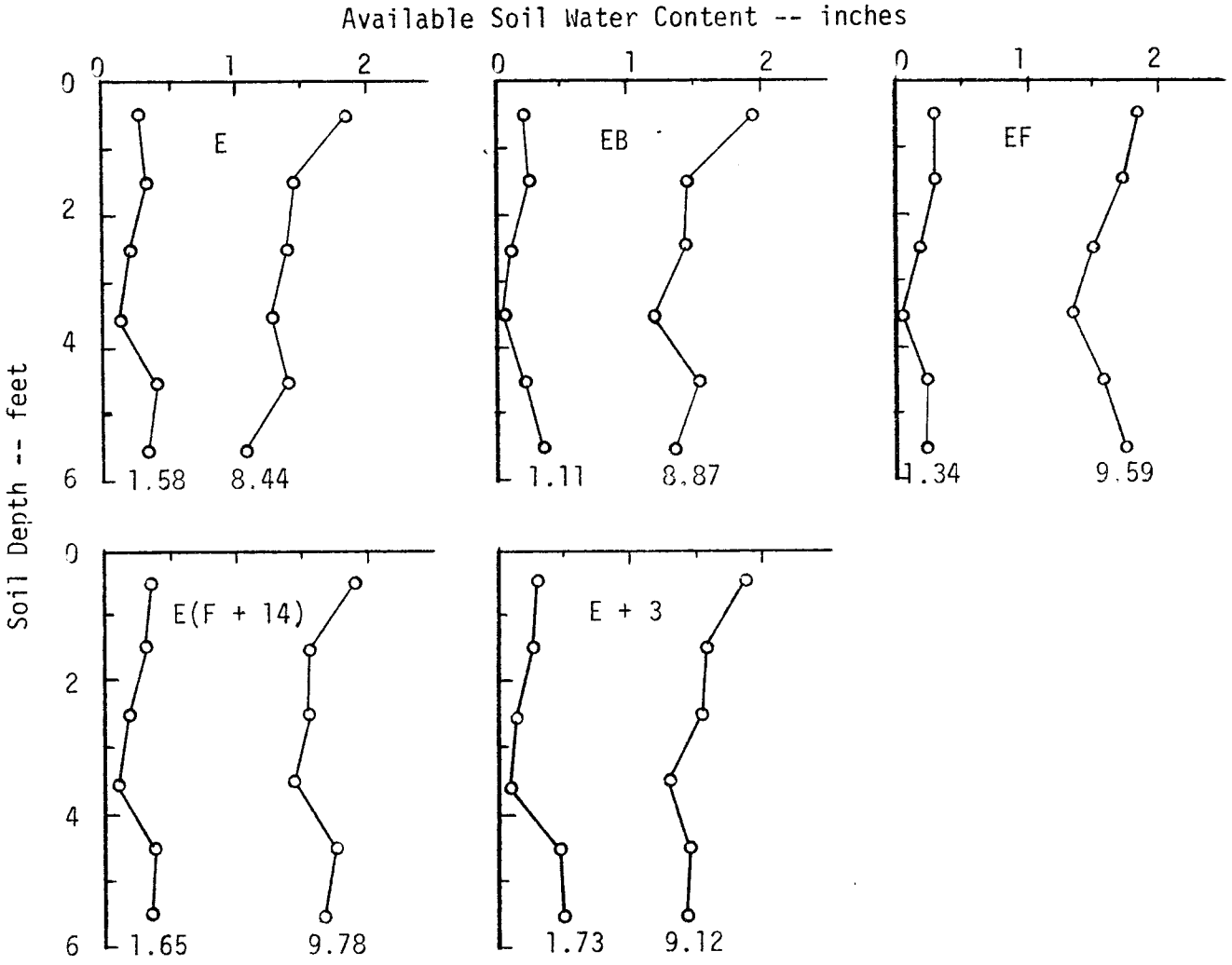

Figure 2. Available soil water contents after emergence (beginning) and after harvest for sunflowers grown under irrigation at Bushland, Texas, in 1975. Numbers below the water content curves indicate total inches of available water in the soil to the 6-foot depth. Treatments were: E---emergence irrigation only; EB---emergence plus one irrigation at early budding; EF---emergence plus one irrigation at early flowering; E(F + 14)---emergence plus one irrigation 14 days after start of flowering; and E + 3---emergence plus three growing season irrigations.

of two rows per plot. The samples were dried, then threshed with a stationary thresher. Table 3 gives seed yields (adjusted to 9% moisture), test weights, and oil contents for the entries in the Performance Trial are given in Table 3.

There were no significant differences among yields of the seven highest yielding entries. Entries 2, 4, and 5 yielded less than the highest yielding entries (12 and 13) and entries 9, 10, and 11 yielded less than most other entries. When yields of the 11 entries common to other performance trials were compared, there were no significant differences among yields for eight of the 11 entries, with only entries 9, 10, and 11 yielding less than most other entries.

Seed test weights differed significantly among entries, with no apparent trends related to yields, except that test weights for Romsun 52 and Peredovik-66 were among the lowest. These entries also had low seed yields. Using either 11 or 13 entries in the test weight analyses caused only slight changes in significant differences among entries. Hybrid 204 and Romsun 52 had significantly lower total oil contents than most other entries. Total oil content differences among the other entries were not significant.

Table 3. Seed yields, test weights, and oil contents for entries in the Sunflower Performance Trial conducted at Bushland, Texas, in 1975.

Entry No.	Hybrid or variety[1/]	Seed source[1/]	Seed yield	Test weight	Total oil content
			lb/acre	lb/bu	%
1	Sunbred 212	Northrup-King & Co.	3072 ab[2/] (a)	32.8 a[2/] (a)	44.5 a (a)
2	Sun-Hi 301	Pacific Oilseeds, Inc.	2702 bc (abc)	28.4 cd (cd)	43.7 a (a)
3	Sun-Gro 372	Growers Seed Assoc.	2885 ab (a)	26.0 e (e)	43.4 a (a)
4	Sun-Gro 380	Growers Seed Assoc.	2749 bc (ab)	29.7 bc (c)	44.5 a (a)
5	Hybrid 201	Cargill, Inc.	2757 bc (ab)	29.0 cd (cd)	43.7 a (a)
6	Hybrid 204	Cargill, Inc.	2994 ab (a)	27.9 d (d)	39.9 bc(bc)
7	Hybrid 8941	Interstate Seed & Grain Co.	2787 abc (ab)	31.3 b (b)	44.7 a (a)
8	Hybrid 8944	Interstate Seed & Grain Co.	2858 ab (ab)	31.1 b (b)	41.8 ab(ab)
9	Romsun 52	Growers Seed Assoc.	2273 d (d)	23.3 f (f)	38.5 c (c)
10	Peredovik-66	Cargill, Inc.	2441 cd (bcd)	26.2 e (e)	42.3 ab(ab)
11	Sputnik-71	Cargill, Inc.	2300 d (cd)	28.9 cd (cd)	42.8 ab(ab)
12[3/]	Hybrid 896	Interstate Seed & Grain Co.	3185 a	27.9 d	44.2 a
13[3/]	cms89 x RHA 272	Experimental	3176 a	29.8 bc	42.7 ab

1/ Names of hybrids, varieties, and seed source are given for the benefit of the reader and do not imply any endorsement or preferential treatment of those listed by the U. S. Department of Agriculture.

2/ Means followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test). Letters in parenthesis apply to the first 11 entries in the trial.

3/ Entries 12 and 13 were not included in the Performance Trial at other locations.

SUNFLOWER HARVESTING RESEARCH---1975

Ronald R. Allen

Hybrid 896 sunflowers were planted to 7 acres in two rows/ 40-inch-spaced bed on April 17. Irrigations were applied on May 28 and July 1. A 2-inch rain occurred on July 22. Plants bloomed in late June and early July. Methyl parathion was applied for sunflower moth control on July 1 and 7.

Paraquat, as a drying aid, was applied to half the field at 0.375 lb/acre on August 11 when head bracts were turning brown and seed moisture was about 25%. Leaf burn was visible in 24 hours. Figure 3 shows the drying pattern of seed and stalks from August 1 to September 25. Seed moisture content of both treated and untreated sunflowers decreased to 10% 7 days after application, while treated and untreated stalks remained at 60 and 69% moisture content (wet basis), respectively.

Treated sunflowers threshed satisfactorily 16 days after treatment, while non-treated sunflowers required an additional 15 days to thresh suitably. The optimum threshing period for treated sunflowers lasted 2 to 3 weeks, after which shatter losses increased. The optimum threshing period for untreated sunflowers lasted about 3 weeks. Seed yield averaged 1,800 lb/acre and oil content averaged 49% for both treated and untreated sunflowers.

Sunflowers were threshed with a 14-foot Allis Chalmers Model "F" combine, using a sunflower header attachment. The sunflower attachment consisted of 9.5 by 48-inch gathering pans extending ahead of the cutting bar. Pans were located on 12-inch centers leaving 2.5-inch stalk slots between pans. Optional 3-inch-long nylon bristle brushes were placed on both sides of slots to test their potential to reduce seed drop. A modified three-slat reel was used.

Stalks from relatively short plants (about 60 inches) fed through the slots and into the auger satisfactorily. Low hanging heads interspersed among tall plants (70-80 inches) required cutting excessive lengths of stalk. These did not feed properly into the auger and feeder-beater when stalk moisture was above 40%.

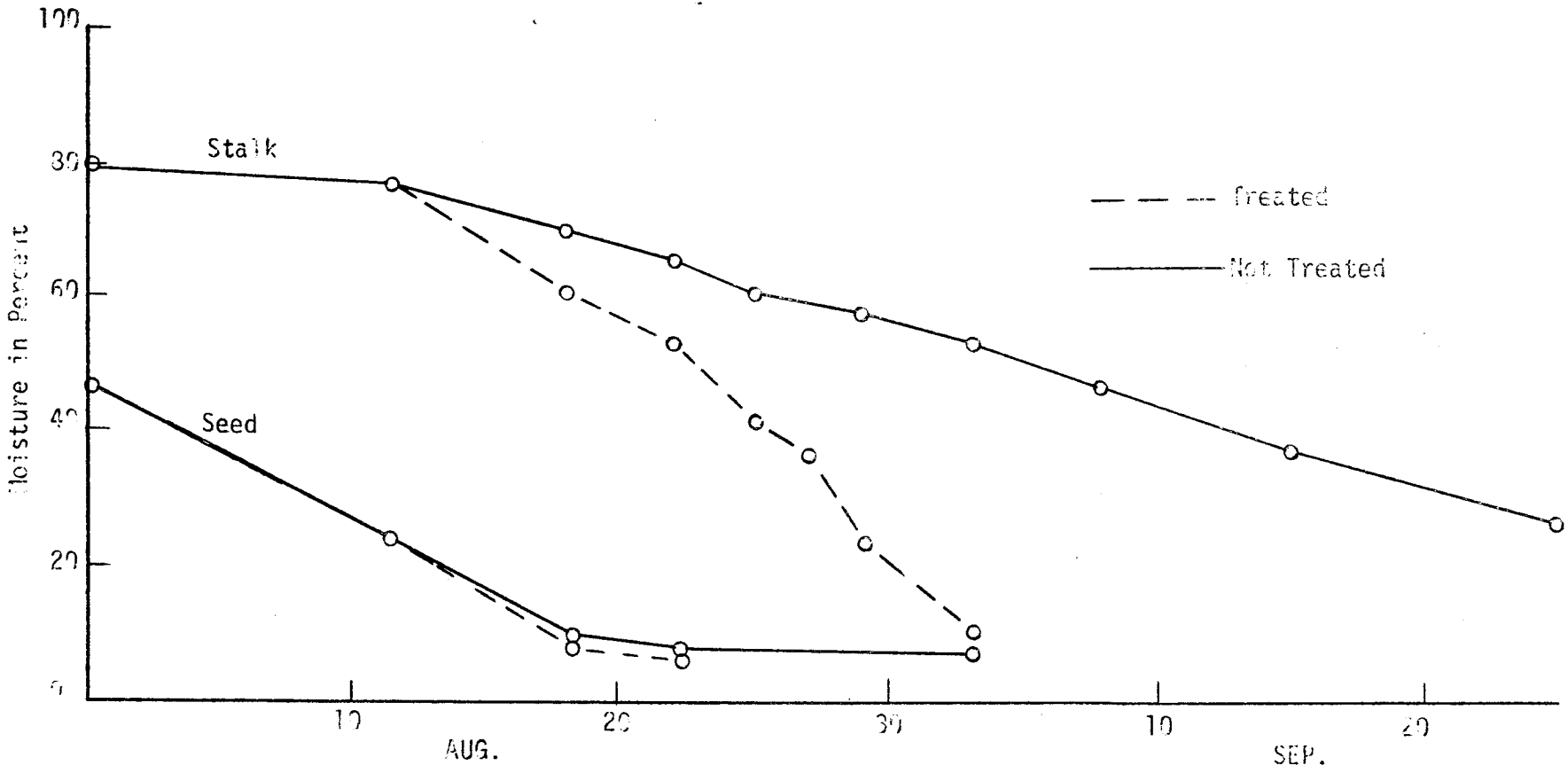

Figure 3. Sunflower seed and stalk drying pattern after chemical treatment (0.375 lb/acre Paraquat) on August 11, 1975 -- USDA Southwestern Great Plains Research Center, Bushland, Texas.

Header losses were measured from 10-square foot areas immediately behind the header, after stopping the machine. Separator losses were measured by catching tailing samples on a 6- by 10-foot tarp. The tarp, attached to a roller on the rear axle, was unrolled as the machine passed through the field. Header losses, which varied from 10 to 35 lb/acre, increased as stalk and head moisture decreased below 30%. The brush option saved from 5 to 20 lb/acre, depending upon moisture. Tailings losses varied from 7 to 35 lb/acre and averaged 15 lb/acre. Header and separator losses totaled 2 to 5% of the 1,800 lb/acre average yield. Header and separator losses and seed trash precentages for given test dates and stalk moisture contents are shown in Table 4.

The combine cylinder was operated at about 300 rpm with a 1/2-inch cylinder-concave clearance. Seed cracking was minimal. Cleaning air and sieve adjustments were set to minimize tail losses without leaving excessive trash in the seed. Openings were set at 5/16 and 1/4 inch, respectively, for upper and lower sieves. Seed trash varied from 1.7 to 6.7% by weight and averaged 3.6%. Trash and head shatter increased when plants remained in the field past optimum dryness.

Table 4. Sunflower harvesting, seed losses, trash percentage, and stalk moisture at varying dates, Bushland, Texas, 1975.

Date	Chem. treat.	Brush attach.	Losses		Trash	Stalk moist.
			Header	Separator		
			lb/acre	lb/acre	%	%
8-27	Yes	Yes	12	15	3.0	36
9-3	Yes	Yes	15	10	2.7	15
	Yes	No	35	10	2.7	15
	No	Yes	11	10	4.1	53
	No	No	15	10	4.1	53
9-10	Yes	Yes	20	35	6.7	45
9-15	Yes	Yes	27	10	4.9	<10
	No	Yes	12	10	3.3	38
9-25	Yes	Yes	35	10		<10
	No	Yes	15	10		25

DRYLAND SUNFLOWER PRODUCTION--1975

Ordie R. Jones

A research project was initiated in 1975 to determine the effects of planting date, plant population, and soil water content at planting on dryland sunflower production. All treatments were replicated three times and data were analyzed by the analysis of variance technique. The treatments were:

1. Soil water content at planting --
   There were three levels of soil water content at planting, which are designated as wet, medium, and dry. Each water level plot was 200 by 500 feet and contained planting date and plant population subplots. Table 5 shows soil water contents at planting. Winter wheat was allowed to grow on the wet and medium water treatments until March 17, when the plots were sweep-plowed to kill the wheat. The wet soil water treatment was obtained by sprinkler applying a total of 4 inches of water on March 18 and 22. The medium and dry water treatments were not sprinkled. Wheat was allowed to grow until April 4 on the dry treatment area to further decrease the soil water content. On April 9, 0.6 inch of water was sprinkler applied to all plots to aid emergence of April 7 planted sunflowers.

2. Planting date --
   Planting dates were April 7, April 24, May 20, June 16, and July 15. Each planting date subplot was 200 by 14 feet with plant population sub-subplots.

3. Plant population --
   Plant populations used were 10,000; 14,000; 18,000; and 22,000 plants/acre. Data are reported only for the first three populations, since dry soil surface conditions limited emergence on some planting dates. Plots were hand-thinned after emergence to the desired plant population.

Table 5. Soil water content at planting and growing season precipitation for dryland sunflowers at Bushland, Texas, in 1975.

Date of Planting	Soil water treatment			Growing season precipitation
	Wet	Medium	Dry	
	inches[1/]			inches
April 7	6.04	4.90	3.69	10.12
April 24	5.85	5.54	4.52	8.95
May 20	4.97	4.61	3.73	8.77
June 16	7.54	6.54	5.31	7.34

1/ Inches of plant available water in the 0- to 6-foot depth.

Table 6. Seed yields and oil contents of dryland sunflowers grown at Bushland, Texas, in 1975.

Date of Planting	Yields				Oil content
	Soil water treatment				
	Wet	Medium	Dry	Mean	Mean
	lb/acre				%
April 7	1/ 1,850	1,590	1,500	1,650 a	47.9 a
April 24	1,660	1,590	1,300	1,520 b	42.9 b
May 20	1,040	1,110	990	1,050 c	37.8 c
June 16	500	510	490	500 d	41.2 b
July 15	540	680	580	600 d	42.4 b

1/ Each yield shown is an average of 3 reps and 3 plant populations. Analysis of variance showed that plant population effects were not significant on yield or oil content. Yields were adjusted to 9% moisture. Means in a column followed by the same letter are not significantly different at the 5% level (Duncan Multiple Range Test).

Hybrid 896 sunflowers were planted with double-disk unit planters in 40-inch rows at 30,000 seeds/acre. Fertilizer was not applied, since P and K were adequate and soil tests showed that 100 lb N/acre was available in the top 3 feet of soil. A preplant application of Treflan controlled weeds. Gravimetric soil water content determinations were made from samples taken to 6 feet at planting and to 8 feet at harvest. Sunflowers were hand-harvested for yield determination.

The effects of planting date were highly significant on seed yield and total oil content (Table 6). Early planted sunflowers produced the highest yields. Part of the yield differences between early and late plantings may have been due to insect and disease control. Beginning at about 10% bloom, sunflowers planted on April 7 and 24 were sprayed three times during bloom with methyl parathion to control sunflower moths. While the May 20, June 16, and July 15 planted sunflowers were blooming, moths were not observed and spraying was discontinued. However, later examination revealed some larvae in these sunflowers. While sunflower moth larvae damage was minor, all heads of the May 20, June 16, and July 15 planted sunflowers were infected with head rot, which probably decreased yields and seed quality. Head rot infection for the April 7 and 24 planted sunflowers was 20 and 27%, respectively. Observations indicated that spraying to control the sunflower moth might also reduce head rot.

The only controlled variable that affected seed total oil content was planting date, which was highly significant (Table 6). Average oil contents for planting dates were highest in April; lowest in May; and then increased again slighlty for the later planting dates.

Increasing the soil water content at planting favorably affected yield, particularly for sunflowers planted on the earlier dates (Tables 5 and 6). The 2.35-inch soil water content difference between the wet and dry treatments of the April 7 planting date resulted in a 350-pound yield increase (Table 6) with each additional inch of available water at planting increasing yields approximately 150 lb/acre. Similar results were obtained for the April 24 planting, but not for later plantings. Head rot possibly decreased or negated the effect of additional available soil water on the later planted sunflowers.

Plant population did not significantly affect seed yield or total oil content. Thus, any population between 10,000 and 18,000 plants/acre should be adequate for dryland production. A population of 10,000 plants/acre on the wet soil treatments resulted in large plants that were difficult to combine. Thus, from a harvesting standpoint, a population of 14,000 plants/acre may be desirable.

Sunflowers used soil water to some depth below 6 feet, but the exact depth could not be determined because samples were taken only to a 6-foot depth at planting. At harvest, the soil water content was at or near the wilting point to the 8-foot depth.

Sunflowers have potential for good production on conservation benches or bench terraces in the Southern High Plains because of their deep rooting, and their ability to efficiently use additional available soil water for increasing yields.

Insects and diseases are major dryland sunflower production problems in the Southern High Plains. Besides sunflower moths and head rot mentioned earlier, girdlers caused some damage. Girdling averaged 7%, but was significantly greater on plots with high plant populations. Maximum girdler damage for any treatment was 14%.

FERTILITY STUDY FOR SUNFLOWERS---1975

Aubra C. Mathers and Bobby A. Stewart

Hybrid 896 sunflowers were planted on check plots (not fertilized since 1972) and on plots that previously had been fertilized with anhydrous ammonia or manure. All plots were cropped to furrow-irrigated grain sorghum for 3 years. Fertility variables for sunflowers were no treatment (check); 75 or 150 lb N/acre (ammonium nitrate) applied in 1975 (to previous check plots); and residual fertility from 200 lb N/acre and 10 or 30 tons manure/acre applied annually for 3 years and 30 tons manure/acre applied 1 year (wet weight basis). The sunflowers were planted on May 16 in one or two rows/40-inch spaced beds at rates to obtain 40,000 plants/acre. However, the maximum plant population obtained was slightly over 25,000 plants/acre. The sunflowers were thinned to 15,000 and 25,000 plants/acre, with one unthinned treatment (slightly higher than 25,000 plants/acre) also was used. The sunflowers received a preplant and three seasonal irrigations.

Yield, oil content, oil yield, test weight, and total N content of sunflower seed data (Table 7) indicated that all fertility treatments resulted in higher seed and oil yields than the check treatment. Yields on plots that received 75 lb N/acre were slightly higher than yields on plots that received 150 lb N/acre (not significant at 5% level), which indicated that sunflowers require little N for seed and oil production. Even residual N, where grain sorghum had been fertilized with 200 lb N/acre for 3 years, produced good yields.

Seed oil contents decreased as seed total N increased. However, the increased yields, when more nitrogen was available for plant growth, resulted in higher oil yields per acre. Total N and test weights increased as the N available for crop growth increased.

Table 8 shows the effects of plant population, row spacing, and fertility on yields. The yield difference between 15,000 and 25,000 plants/acre was 87 lb/acre, which was statistically significant. However, the 2,379 and 2,439 lb/acre average yields for 1- and 2-rows/bed were not significantly different.

Table 7. Seed yields, total oil contents, oil yields, test weights and total nitrogen contents of sunflowers grown on nitrogen fertilized and residual fertility plots (from nitrogen and manure treatments) at Bushland, Texas, in 1975.

Treatments	Seed yield[1/]	Total oil content	Oil yield	Test weight	Total N content
	lb/acre	%	lb/acre	lb/bu	%
Nitrogen					
Check	1,745 c[2/]	48.5 a	846 b	23.9 d	2.40 e
75 lb/acre	2,545 ab	43.8 b	1,116 a	24.1 cd	3.29 d
150 lb/acre	2,463 b	42.9 bc	1,058 a	24.2 cd	3.46 bc
200 lb/acre (residual)	2,397 b	43.6 b	1,048 a	24.3 cd	3.42 bc
Manure					
10 tons/acre	2,502 ab	42.9 bc	1,075 a	24.6 bc	3.39 cd
30 tons/acre	2,657 a	42.1 c	1,121 a	25.7 a	3.77 a
30 tons/acre (1 yr)	2,557 ab	42.4 c	1,086 a	24.9 b	3.54 b

1/ Adjusted to 9% moisture content.

2/ Means in a column followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).

Table 8. Sunflower seed yields as affected by fertility, row spacing, and plant population at Bushland, Texas, in 1975.

Treatments	Plant populations--thousands/acre 15	25	40	Average
	lb/acre			
	One row/bed			
Nitrogen				
Check	1,934	1,787	1,540	1,754
75 lb/acre	2,485	2,523	2,652	2,554
150 lb/acre	2,342	2,718	2,475	2,512
200 lb/acre (residual)	2,347	2,264	2,463	2,358
Manure				
10 tons/acre	2,331	2,575	2,302	2,403
30 tons/acre	2,462	2,791	2,753	2,669
30 tons/acre (1 yr)	2,463	2,357	2,397	2,406
Average	2,338	2,431	2,369	2,379
	Two rows/bed			
Nitrogen				
Check	1,702	1,765	1,740	1,736
75 lb/acre	2,502	2,644	2,460	2,535
150 lb/acre	2,350	2,662	2,231	2,414
200 lb/acre (residual)	2,363	2,374	2,571	2,436
Manure				
10 tons/acre	2,423	2,703	2,675	2,600
30 tons/acre	2,729	2,524	2,682	2,645
30 tons/acre (1 yr)	2,704	2,674	2,747	2,708
Average	2,396	2,478	2,444	2,439
Population average	2,367	2,454	2,406	

Table 1. Seed yields for sunflowers irrigated at different growth stages in 1976 at Bushland, Texas. Yields for 1975 and 2-yr average yields, where applicable, are included.

Treatments[1/]	Irrigation dates -- 1976	Seed yields -- lb/acre		
		1975	1976	2-yr Av.
E	May 17	1410 d[2/]	730 d[2/]	1070
EB	May 17, June 30	1960 c	1340 bc	1650
EF	May 17, July 9	2470 b	1400 b	1930
E (F+14)	May 17, July 23	2740 ab	1060 cd	1900
EB (F+14)	May 17, June 30, July 23	--	2040 a	--
EF (F+14)	May 17, July 9, July 23	--	1660 b	--
E + 3	May 17, June 22, July 9, July 23	2970 a	2080 a	2520

1/ Irrigation treatments were: E -- emergence only; EB -- emergence and early budding; EF -- emergence and early flowering; E (F+14) -- emergence and 14 days after start of flowering; EB (F+14) -- emergence, early budding, and 14 days after start of flowering; EF (F+14) -- emergence, early flowering, and 14 days after start of flowering; and E + 3 -- emergence and three growing-season irrigations.

2/ Column values followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).

Table 2. Plant height, seed test weight and oil content, growing-season water use, and water-use efficiency for sunflowers irrigated at different growth stages in 1976 at Bushland, Texas

Treatment[1/]	Plant height at flowering (in.)	Seed test weight (lb/bu)	Total oil content (%) [2/]	Growing-season water use				WUE (lb/acre-in.)
				Irrig. (in.)	Precip. (in.)	Soil (in.)	Total (in.)	
E	34 d[3/]	30.0 a[3/]	44.9 a[3/]	3.0	6.2	3.0	12.2	60.0
EB	46 b	28.3 b	41.9 cd	6.0	6.2	3.6	15.8	84.6
EF	38 c	26.2 c	40.1 e	6.0	6.2	2.6	14.8	94.3
E (F+14)	34 d	28.6 b	44.1 ab	6.0	6.2	2.4	14.6	72.3
EB (F+14)	46 b	27.7 b	43.2 bc	9.0	6.2	3.8	19.0	107.5
EF (F+14)	37 cd	26.3 c	41.6 cd	9.0	6.2	2.9	18.1	91.4
E + 3	54 a	25.7 c	41.0 de	12.0	6.2	2.2	20.4	101.8

1/ Irrigation treatments were: E -- emergence only; EB -- emergence and early budding; EF -- emergence and early flowering; E (F+14) -- emergence and 14 days after start of flowering; EB (F+14) -- emergence, early budding, and 14 days after start of flowering; EF (F+14) -- emergence, early flowering, and 14 days after start of flowering; and E + 3 -- emergence and three growing-season irrigations.

2/ Determined by the nuclear magnetic resonance technique on moisture-free samples.

3/ Column values followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).